

**APPENDIX H -- ANALYSIS OF SIMULATED LONG-TERM MEAN DAILY SALINITY FROM SITES ALONG THE NORTHWEST FORK OF THE LOXAHATCHEE RIVER**

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**INTRODUCTION**

Floodplain vegetation along downstream segments of the Northwest Fork of the Loxahatchee River has changed over the past century from freshwater swamp dominated by bald cypress and wetland hardwoods to salt-tolerant red mangrove swamp. In order to identify salinity conditions that may lead to changes in freshwater floodplain vegetation, District staff compiled historical flow and measured salinity data from the River, and conducted vegetation surveys in order to relate salinity to vegetation community characteristics. Since long-term salinity sampling data were not available from all sites where vegetation survey data is available, a hydrodynamic/salinity model was used to simulate salinity conditions at several upstream river sites for a 30-year period of record. The details of the hydrodynamic/salinity model, including its development and verification, can be found in **Appendix E** of this report.

The simulated long-term mean daily salinity for each of seven sites along the NW Fork were statistically analyzed to examine trends relative to proximity to the Jupiter Inlet, the primary source of salinity to the River. In addition to descriptive statistics, the

simulated salinity was categorized into salinity events to make it more appropriately relatable to vegetation response. The following report presents the simulated salinity time series, describes the methods used to analyze the time series, and the results of the analysis.

## METHODS

### ***Analysis of Historical Daily Average Salinity***

Long-term, continuous salinity records (e.g., multi-decade) do not exist for the Loxahatchee River or estuary. Because changes in floodplain community structure have occurred gradually over the past 50 years (see **Appendix B**), a method to generate an estimated time series of historical salinity was developed as a means to compare long-term salinity conditions at a site with vegetation community changes through time. A long-term (30 year) daily salinity data set was estimated using current (1994-2000) flow/salinity relationships developed for the NW Fork (see **Appendix D**) and long-term (30 year) historical flows from Lainhart Dam using the RMA-2/RMA-4 hydrodynamic salinity model (USACE 1996). The model was developed specifically for the Loxahatchee River using methods described in **Appendix E**. A 30-year period of record (POR) of mean daily salinity, which extended from April 1971 through January 2001, was simulated for each of eight sites (**Table H-1, also see Figure C-2 for a map of the location of these sites along the NW Fork**). From these data SFWMD staff plotted individual time series, and calculated descriptive statistics (mean, standard deviation, median, mode and maximum daily salinity concentrations) for each site. Other analysis included calculation of the percent of time that salinity was equal to or above a particular threshold value (e.g., 1 ppt, 2 ppt, 3 ppt, etc.), and the determination of the mean salinity event duration and the mean time between salinity events (i.e. salinity event analysis).

The salinity event analysis grouped the simulated salinity data from a site into salinity events that equaled or exceeded a particular salinity threshold. For example, at a threshold of 2 ppt or greater, a salinity event was defined as the number of continuous days that the simulated salinity time series was at or above this value. The mean number of days (duration) of each salinity event (*Ds*) and the mean number of days between events (*Db*) at each site (**Table H-1**) were derived for the POR. Salinity conditions at a site were expressed in terms of *Ds* and *Db* for a minimum threshold value in order to relate it to vegetation community characteristics. In terms of potential effects of salinity exposure (or any toxic substance) on freshwater vegetation, the magnitude

(concentration) and duration of exposure to elevated salinity levels is related to the extent of damage to the freshwater community caused by that exposure (see Pezeshki et al. 1986, 1987, 1990, 1995; Conner & Askew 1992; Allen 1994; Allen et al. 1994, 1997). The time between salinity events is also important to allow sufficient recovery from the last damaging salinity event.

A ratio of the salinity event duration and time between events ( $Ds/Db$ ) was calculated to provide a single numeric value to express the salinity characteristics at a specific site and to reduce the number of factors in the analysis. Event duration and time between events can be expressed in any time scale (days, weeks, months), however in our application we have used days as the standard unit of measure for this ratio. A  $Ds/Db$  ratio of 1 indicates that half of the time average daily salinity at a site is at or above the selected threshold.  $Ds/Db$  ratio values that are increasingly larger than 1 indicate more predominantly saltwater conditions at a site. This ratio decreases consistently as one travels upstream from the Jupiter Inlet and becomes zero as constant freshwater conditions are observed. For this reason, the  $Ds/Db$  ratio was useful as a general index of salinity at a given location along the River.

**Table H-1. Sites along the Northwest Fork of the Loxahatchee River where Long-Term Mean Daily Salinity Time Series were Simulated**

Site Name	Site Location
Vegetation Site 7-C, Water Quality Monitoring Site #64	River Mile 7.8
Vegetation Site 8-B	River Mile 8.4
Vegetation Site V-6, Water Quality Monitoring Site #65	River Mile 8.6
Vegetation Site 8-D (8-st)	River Mile 8.9
Vegetation Site 9-B	River Mile 9.2
Water Quality Monitoring Site #66	River Mile 9.4
Vegetation Site 9-C	River Mile 9.7
Vegetation Site 10-B	River Mile 10.2

## RESULTS AND DISCUSSION

### ***Estimation of a Historical Mean Daily Salinity Time Series***

Using the hydrodynamic salinity model developed for the Loxahatchee River and Estuary (see **Appendix E**) and historical flow data for Lainhart Dam and other tributaries which drain into the NW Fork, we estimated the mean daily salinity concentrations at seven sites (**Table H-1**) along the NW Fork. The summary statistics from the result of this model run are shown in **Table H-2**.

**Table H-2. Summary Statistics of the Estimated Mean Daily Salinity Concentrations for the 30 Year Period of Record**

Site Name	River Mile	Daily Salinity			
		Mean $\pm$ St. Deviation	Median	Mode	Maximum
7-C (WQ Sta. #64)	7.8	6 $\pm$ 5	5	0	21
8-B	8.4	4 $\pm$ 4	2	0	18
WQ Sta. #65	8.6	3 $\pm$ 3	1	0	16
8-D	8.9	2 $\pm$ 3	1	0	14
9-B	9.2	1 $\pm$ 2	0	0	9
9-C	9.7	0 $\pm$ 1	0	0	6
10-B	10.2	0 $\pm$ 0	0	0	3

In order to express long-term salinity conditions at a site in terms of effects on the vegetation community, we organized the data into “salinity events”. In this analysis, it was assumed that a “threshold” of salinity exists above which an impact occurs to a plant species. Along upstream segments of the NW Fork, a salinity event at or above a specific threshold occurs for a number of days at a site, which is followed by a period of time where freshwater conditions return and recovery from the salinity impact occurs. To capture this salinity impact-recovery cycle and the net effect it may have on the freshwater plant community, the long-term salinity data was examined in terms of salinity event duration (*Ds*) and elapsed time between events (*Db*) for a particular

threshold. **Table H-3** shows the duration of salinity concentrations at or above several selected threshold values for the modeled period of record. **Table H-4** shows the mean duration of salinity events and the mean time between salinity events at or above the selected threshold values for the modeled period of record. Salinity event ratios  $Ds/Db$  along the NW Fork show a negative correlation with distance from the Jupiter Inlet. As one moves upstream, the  $Ds/Db$  ratio approaches zero as fewer salinity events occur. In contrast, the  $Ds/Db$  ratio exceeds one and rapidly increases downstream as the magnitude and duration of each salinity event increases, and the time between salinity events decreases. An example of the  $Ds/Db$  relationship is shown in **Figure H-1** for a salinity threshold of  $\geq 2$  ppt.

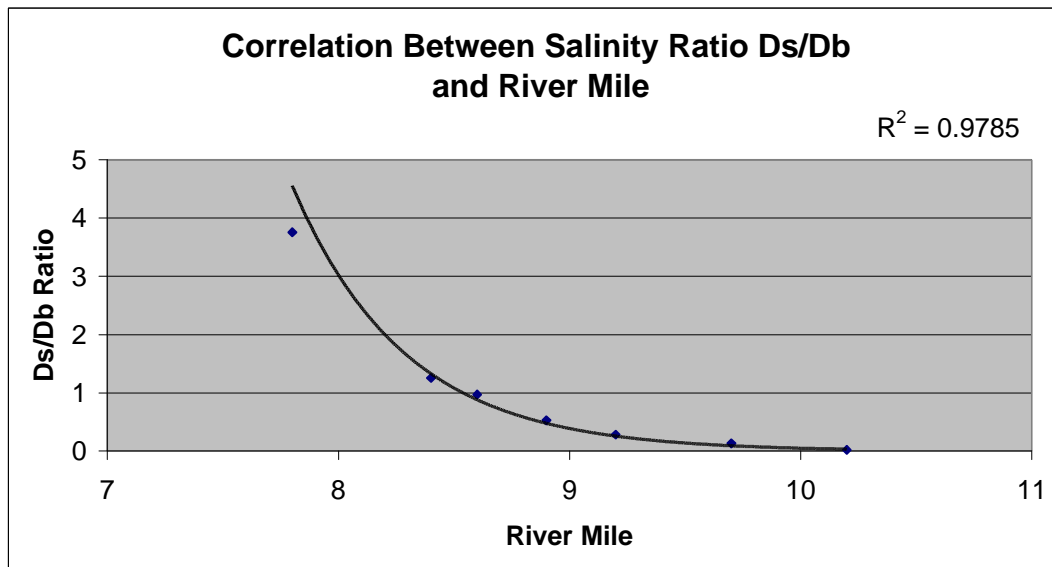
**Table H-3. Duration of Estimated Mean Daily Salinity Concentrations from the 30 Year Period of Record for Several Selected Threshold Values at Sites along the NW Fork**

Site	River Mile	Number of Days (Percent of Time) at or above Threshold			
		$\geq 1$ ppt	$\geq 2$ ppt	$\geq 3$ ppt	$\geq 4$ ppt
7C (#64)	7.8	9252 (84.9%)	7913 (72.6%)	6689 (61.4%)	5831 (53.5%)
8B	8.4	7038 (64.6%)	5496 (50.4%)	4613 (42.3%)	3873 (35.5%)
WQ #65	8.6	5870 (53.9%)	4562 (41.9%)	3666 (33.6%)	3013 (27.6%)
8D	8.9	4525 (41.5%)	3297 (30.3%)	2497 (22.9%)	1959 (18.0%)
9B	9.2	3071 (28.2%)	1953 (17.9%)	1297 (11.9%)	834 (7.7%)
9C	9.7	1870 (17.2%)	906 (8.3%)	418 (3.8%)	161 (1.5%)
10B	10.2	568 (5.2%)	113 (1.0%)	14 (0.1%)	0 (0.0%)

**Table H-4. Mean Salinity Event Duration (days) and Time between Events (days) from Estimated Mean Daily Salinity along the NW Fork of the Loxahatchee River**

Site	River Mile	Mean Duration ( <i>Ds</i> ) and Time Between ( <i>Db</i> ) Salinity Events									
		$\geq 1$ ppt		$\geq 2$ ppt		$\geq 3$ ppt		$\geq 4$ ppt		$\geq 5$ ppt	
		<i>Ds</i>	<i>Db</i>	<i>Ds</i>	<i>Db</i>	<i>Ds</i>	<i>Db</i>	<i>Ds</i>	<i>Db</i>	<i>Ds</i>	<i>Db</i>
7C (#64)	7.8	157	14	76	20	50	26	44	33	44	43
8B	8.4	83	23	49	39	52	62	48	77	45	94
WQ #65	8.6	67	30	68	70	58	85	56	111	40	124
8D	8.9	54	52	47	90	46	130	37	144	35	191
9B	9.2	61	101	45	157	47	292	38	364	39	602
9C	9.7	44	126	43	341	35	569	30	1063	21	1799
10B	10.2	40	322	33	1333	23	3618	0	0	0	0

**Figure H-1. Correlation between Salinity Event Ratio *Ds/Db* (>2 ppt) and River Mile**



## CONCLUSIONS

Salinity characteristics at sites along the NW Fork are highly correlated to distance from the Jupiter Inlet. Generally the magnitude and duration of salinity conditions decrease as one moves upstream along the River, with predominantly freshwater conditions occurring above river mile 10 for the simulated long-term salinity time series. A categorization of the salinity time series into salinity events proved useful for combining three separate factors (salinity magnitude, duration of a salinity event, and time between salinity events) into a single numeric value.

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